has to traverse an extended surface of dry land, the former, as a rule, even appears as a rainy wind, while the latter, if its course have been *long* enough, appears as a dry wind; and if the mountain range be high enough, which the latter is required to rise over, this may, when it has reached the other side, even stream down as a hot, withering wind, the föhn of Continental writers, on the thirsty regions. If, then, we find in coast districts a greater yearly rainfall than further inwards, or if, on the wind side of the hills, we find lower snow-lines and further-reaching terminal moraines of the glaciers than on the lee side; or lastly, if we find successively regions of forests, of steppes, and of wastes, we may easily recognise therein each time an expression of the power of the winds, which, according as they are abundantly or poorly laden with aqueous vapour, or even quite dry, call forth this variety of geophysical phenomena.

The ever-moving atmosphere has therefore the most heterogeneous actions. While it feeds the glaciers and rivers, it causes at the same time a backward prolongation of these to the common source of the water—to the ocean, so as, with its moist breath, to produce everywhere simultaneously a formation of humus, and awake all into life; and again, where it is otherwise—where it appears as by nature a dry wind, or has been deprived of its freight of water, it brings with it drought and death. In the deserts the flora and fauna, then, have an extremely poor existence; the rivers no longer flow in a regular course; they have already been long in retreat, or are still only intermittent in their flow; the lakes also, when they are to be found in deserts, continually lose, through the constant evaporation, an abundance of water, although they may long have ceased to have an outlet to the neighbouring sea. In many deserts you do not meet with a single brook or pond; instead of such, you find only dried-up wadis and depressions, while the extensive stretches of waste, covered with salt incrustations and efflorescences, as also the scattered remains of dead animal species of past times, give evidence that these waste and withered regions formerly wore quite a different physiognomy; indeed, as the fossils and deposits of gypsum and salt testify, must even have been flooded with enormous inland seas. Now, probably (next to solar heat), it was above all, the winds, especially the dry winds, which, acting for a long period of time in the earth's history, dissolved these seas into aqueous vapour, carried them away, and so transformed the former lake bottom, now laid bare, into a waste.

Second Part.—But the winds are not only an expression for the general circulation of the air and aqueous vapour of the ocean; they are also a moving agent *quand même* not to be underestimated, since, in their progress, they communicate their own motion to all bodies which are not heavy enough to withstand them. Now, according as, in this way, solid or liquid bodies (especially the waters of the ocean) are put in motion, the mechanical action of the winds is to be considered from two distinct standpoints; first, its action on the solid land, and second, on the water, and through this again upon the solid land.

In the first case, it is the conditions of the strata that are continually altered under the action of the winds. It is at one time the snow, at another the salt-dust, at another the vegetable and animal remains, the ashes thrown out in volcanic eruptions, masses of dust and *débris*, or lastly, sand, that are whirled about, raised, carried miles away, and again deposited. The so-called wind-bedding characterises in every case the formations so produced, or in course of production. We shall cite here only two of the most remarkable examples of this kind of power in winds. One is the extensive Chinese Loess formation, which, according to von Richthofen's researches, appears to be quite a wind-formation; the other is the progressive dune-formation and dune-shifting on flat sandy coasts. Closer investigations (in this connection) of the conditions under which dunes are generally formed, examinations of their form, slope, and strike, and further, some materials furnished in the narratives of travel of Rohlfs and Dr. Tietze, have enabled the author to form a new theory as to the origin of sandy wastes, but especially to show that, as a rule, they are simply dune-formations on the shores of the former inland lake which has disappeared through evaporation. Some examples of sand scratches, sand cuttings, and the devastations wrought by hurricanes, illustrate the further mechanical action of the winds on the dry land.

Passing to the mechanical action of winds on water, we have, above all, to consider drift-currents (wind-drifts) and the motion of wind-waves. But while the former manifest themselves as powerful factors of transport, the wind-waves are besides characterised by a not unimportant effect in the direction of depth, but more especially by their now land-forming, now land-shattering surge. In this way the waters appear also as the most powerful medium through which the action of the winds is exerted on the solid land. In fact it is the capricious wind-wave that destroys and carries away whole stretches of coast in order to raise somewhere else and lay dry whole areas out of the oceanic depths (sand bars, sandbanks, flat coasts, delta formations, &c.). It is the wind-wave that ever renders active the principle of constant transformation in opposition to that of stability, and seeks to alter the contours of the dry land. Not without reason, then, does El. Reclus remark:—"It is by the movement of the atmosphere that we have to explain the form of continents." (*C'est par les mouvements de l'atmosphère, qu'il faut expliquer la forme des continents.*)

Third Part.—The winds, finally, produce, in an indirect way, many geological phenomena. According as they influence and determine the air-pressure, they cause now a perceptible swelling out, now a sinking of some large water surface, as has been observed on the oceans as well as on the North American and the Swiss lakes. Through this influence of air-pressure the winds further appear to affect volcanoes now favourably, now preventively—since also the lava masses in the crater (according to P. Scrope's representation) must be sensitive to atmospheric pressure; in high pressure finding a greater resistance, and in low pressure rising and breaking out more easily. The firedamp explosions also appear to be favoured by barometric depression. Similarly a certain connection can be demonstrated between the air-pressure and earthquakes.

Still more evidently are winds seen to exert an influence on earthquakes and volcanic phenomena, when regarded as rain-winds. With a large access of atmospheric water are connected both subterranean deluges and overturnings, and an abundant formation of steam in the heart of volcanoes; these circumstances immediately give rise to earth-tremblings, or violent volcanic outbursts and exhalations of steam.

If the hypothesis of T. R. Mayer, that the trade-winds are the principal cause of terrestrial magnetism, be correct, we must also, finally, ascribe to the winds an important part in the production of electricity. Lyon, Duveyrier, and Rohlfs have observed that the dry desert wind is uncommonly rich in electricity.

The author, indeed, has, in the course of his researches, given attention especially to the action of the winds in the most recent geological periods, and must in the meantime leave to specialists the more definite answering of the question how far the traces of action of winds also in the older periods of the earth's history can be followed. It is certain, however, that since in historical geology we have to do with a land flora and fauna, and with the (wrongly) so-called ocean precipitate, and so with the building up of sedimentary layers, we have so many undoubted proofs of the existence of rain and rivers, and accordingly of that of winds. Even when the earth was still a ball of glowing gas—and consequently a sort of sun to the moon's inhabitants, we can conceive the wind already acting as a geological agent—with the proviso, indeed, that the theory (of Faye and Reye) which regards the sun-spots as cyclone-like phenomena, or Secchi's view that the temperature of the sun at the sun's equator is higher than beyond the 30th degree of latitude, be verified.

UNDERGROUND TEMPERATURE[1]

A REMARKABLE series of observations have recently been taken in a boring at Sperenberg, near Berlin. The bore was carried to the depth of 4,052 Rhenish (or 4,172 English) feet, and was entirely in rock salt with the exception of the first 283 feet, which were in gypsum with some anhydrite. The observations were taken under the direction of Herr Eduard Dunker, of Halle-an-der-Saale, and are described by him in a paper occupying thirty-two closely printed quarto pages (206-238) of the *Zeitschrift für Berg-Hütten-und-Salinen-Wesen* (xx. Band, 2 und 3 Lieferung, Berlin, 1872).

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[1] Ninth Report of the British Association Committee, consisting of Prof. Everett, Sir W Thomson, F.R.S, Prof. J. Clerk Maxwell, F.R.S., G. J. Symons, F.M.S., Prof. Ramsay, F.R.S., Prof. A. Geikie, F.R.S., James Glaisher, F.R.S., George Maw, F.G.S., W. Pengelly, F.R.S, Prof. Hull, F R.S., Prof. Ansted, F.R.S., Prof. Prestwich, F.R.S., Dr. C. Le Neve Foster, Prof. A. S. Herschel, G. A. Lebour, F.G.S., and A. B. Wynne, appointed for the purpose of investigating the Rate of Increase of Underground Temperature downwards in various Localities of Dry Land, and under Water. Drawn up by Prof. Everett, Secretary.

The instrument employed for measuring the temperatures was the earth-thermometer of Magnus, which gives its indications by the overflowing of mercury, which takes place when the instrument is exposed to a higher temperature than that at which it was set. To take the reading, it is immersed in water a little colder than the temperature to be measured; the temperature of this water is noted by means of a normal thermometer, and at the same time the number of degrees that are empty in the earth-thermometer is noted. From these data the maximum temperature to which the instrument has been exposed can be deduced, subject to a correction for pressure, which is not very large, because the same pressure acts upon the interior as upon the exterior of the thermometer.

In the following *résumé* (as in the original paper) temperatures are expressed in the Réaumur scale, and depths in Rhenish feet, the Rhenish foot being 1·029722 English foot.

Observations were first taken at intervals not exceeding 100 feet, from the depth of 100 feet to that of 4042 feet, the temperature observed at the former depth being 11·0, and at the latter 38·5; but all these observations, though forming in themselves a smooth series, were afterwards rejected, on the ground that they were vitiated by circulation of water and consequent convection of heat.

It has often been supposed that though this source of error may affect the middle and upper parts of a bore, it cannot affect the bottom; but the Sperenberg observations seem to prove that no such exemption exists. When the bore had attained a depth of nearly 3,390 feet, with a diameter of 12 inches 2 lines at the bottom, an advance bore of only 6 inches' diameter was driven 17½ feet further. A thermometer was then lowered half-way down this advance bore, and a plug was driven into the mouth of this advance bore so as to isolate the water contained in it from the rest of the water above. After twenty-eight hours the plug was drawn and the thermometer showed a temperature of 36·6. On the following day the temperature was observed at the same depth without a plug, and found to be 33·6. Another observation with the plug was then taken, the thermometer (a fresh instrument) being left twenty-four hours in its position. It registered 36·5, and again, without plugging, it gave on the same day 33·9. It thus appears that the effect of convection was to render the temperature in the advance bore 3° R. too low.

Apparatus was then employed for isolating any portion of a bore by means of two plugs at a suitable distance apart with the thermometer between them. This operation was found much more difficult than that above described, but in several instances it gave results which were deemed quite satisfactory; while in other instances the apparatus broke, or the plugging was found imperfect. The deepest of the successful observations by this method was at 2,100 feet, and the shallowest was at 700 feet. The first 444 feet of the bore was lined with iron tubes, between which the water had the opportunity of circulating even when the innermost tube was plugged, hence the observations taken in this part were rejected.

All the successful observations are given in the third column of the following table, subject to a correction for pressure; and, for the sake of showing the error due to convection in the ordinary mode of observing, the temperatures observed at the same depths when no plugs were used, are given in the second column:—

Depth in feet.	Temperature Réaumur.		Difference.
	Without plugging.	With plugging.	
700	16·08	17·06	0·98
900	17·18	18·5	1·32
1,100	19·08	20·8	0·72
1,300	20·38	21·1	0·72
1,500	22·08	22·8	0·72
1,700	22·9	24·1	1·2
1,900	24·8	25·8	1·0
2,100	26·8	27·1	0·3
3,390	34·1	36·15	2·05

These temperatures are not corrected for pressure, but they are corrected for rise of zero in the normal thermometer; and this last circumstance explains the difference of 0·4 between the temperature 36·15 here given and 36·55, which is the mean of the above-mentioned observations at the depth of 3,390 feet.

Another proof of the injurious effect of convection was obtained by comparing the observed temperatures (without plugging) in the first 400 feet of the great bore, designated Bore I., with the temperatures observed at the same depths during the sinking of another bore, designated Bore II., near it; the observations in this latter being always taken at the bottom. The following were the results:—

Depth Feet.	Temperatures.	
	Bore I.	Bore II.
100	11·0	9·0
200	11·6	10·4
300	12·3	11·5
400	13·6	12·5

The temperature at the depth of 100 feet in the great bore thus appears to have been raised about 2° R. by convection.

The following is a table of the successful observations, corrected for pressure:—

Depth in Rhenish feet.	Temperature Réaumur.
700	17·275
900	18·780
1,100	21·147
1,300	21·510
1,500	23·277
1,700	24·741
1,900	26·504
2,100	28·668
3,390	37·238

Assuming, with Herr Dunker, the mean temperature of the surface to be 7·18, which is the mean annual temperature of the air at Berlin, we have the following increments of temperature with depth:—

Depths in Rhenish feet.	Increment of depth.	Increment of temperature.	Increase per 100 feet deg. Réau.	Increase per 100 feet deg. Fahr.
0 to 700	700	10·095	1·442	3·24
700 to 900	200	1·505	·752	1·69
900 to 1,100	200	2·367	1·184	2·66
1,100 to 1,300	200	0·363	·182	·41
1,300 to 1,500	200	1·767	·884	1·99
1,500 to 1,700	200	1·464	·732	1·65
1,700 to 1,900	200	1·763	·882	1·98
1,900 to 2,100	200	2·164	1·082	2·43
2,100 to 3,390	1,290	8·570	·664	1·49
0 to 3,390	3,390	30·058	·887	2·00

The mean rate of increase found by comparing the temperatures at the surface and 3,390 feet is exactly 1° Fahr. for 50 Rhenish or 51·5 English feet.

The numbers in the last two columns exhibit upon the whole a diminution with increase of depth; in other words, the temperature increases less rapidly as we go deeper down. As regards the first 700 feet, which exhibit a decidedly more rapid rate than the rest, it must be remembered that nearly half of this distance was in a different material from the rest of the bore, being in gypsum with some anhydrite, while all the rest was in rock salt. Prof. Herschel has found, in recent experiments not yet published, that the conductivity of rock salt is exceedingly high; and theory shows that the rates of increase, in superimposed strata, should be inversely as their conductivities. We may, therefore, fairly attribute the rapid increase in the first 700 feet to the relatively small conductivity of the portion (283 feet) which is not rock salt. The slow rate of increase observed in the long interval between the depths of 2,100 and 3,390 feet is not so easily accounted for; we can only conjecture that this and the other inequalities which the above table presents, for depths exceeding 700 feet, are due to fissures or other inequalities in the rock which have not been put in evidence.

With the view of summing up his results in small compass, Herr Dunker has assumed the empirical formula—

$$t = 7{\cdot}18 + ax + bx^2,$$

t denoting the temperature (Réaumur) at the depth x (Rhenish feet); and has computed the most probable values of a and b, by the method of least squares. He finds

$$a = {\cdot}0129857 \qquad b = -\,{\cdot}000000125791,$$

the negative sign of b indicating that the increase of temperature becomes slower as the depth increases.

A paper by Prof. Mohr, of Bonn, as represented by an abstract published in NATURE (vol. xii. p. 545), has attracted attention from the boldness of its reasoning in reference to the Sperenberg observations. Prof. Mohr, however, does not quote the observations themselves, but only the temperatures calculated by the above formula, which he designates, in his original paper (*Neues Jahrbuch für Mineralogie*, &c., 1875, Heft 4), "the results deduced from the observations by the method of least squares." In the abstract in NATURE they are simply termed "the results of the thermometric investigation of the Sperenberg boring," a designation which is still more misleading.

Attention is called to the circumstance that the successive increments of temperature for successive equal increments of depth, form an exact arithmetical progression, as if this were a remarkable fact of observation, whereas it is merely the result of the particular mode of reduction which was adopted, being a mathematical consequence of the assumed formula $t = 7{\cdot}18 + ax + bx^2$. The method of least squares is not responsible for this formula, but merely serves, after this formula has been assumed for convenience, to give the best values of a and b.

Herr Dunker, in his own paper, lays no stress upon the formula, and gives a caution against extending it to depths much greater than those to which the observations extend. Writing to Prof. Everett under date April, 1876, he requests that in the summary of his results to be given in the present Report, the formula should either be suppressed or accompanied by the statement that its author reserves a different deduction.

The following are the differences between the temperatures computed by the formula and the observed temperatures:—

Depth.	Difference (computed *minus* observed).
700	− 1·621
900	− 0·931
1,100	− 1·204
1,300	+ 0·427
1,500	+ 0·553
1,700	+ 0·882
1,900	+ 0·811
2,100	+ 0·238
3,390	+ 0·482

The necessity of adopting some means to prevent the circulation of water in bores, has for some time been forcing itself upon the attention of your Committee. Many of the observations taken by their observers have contained such palpable evidence of convection as to render them manifestly useless for the purpose intended; and in the light of the Sperenberg experiments it is difficult to place much reliance on any observations taken in deep bores without plugging. The selection of a suitable form of plug is now occupying the careful attention of your Committee.

Herr Dunker's paper gives a very full account of the different kinds of plug employed at Sperenberg.

For stopping the mouth of the advance-bore the plug had a tapering shape, and was of hard wood, strengthened by two iron rings, one at each end, and covered with a layer of tow 5 lines thick, outside of which was thick and strong linen, nailed above and below to the wood, through a leather strap. It was lowered into its place by means of the iron rods used for boring; and, when in position, was pressed home by a portion of the weight of the rods. The plug carried the thermometer suspended from it. Its extraction was commenced by means of a screw on the beam of the boring machine, in order to avoid a sudden jerk, which might have broken the thermometer. The force which was found necessary for thus starting the plug, as well as the impression observed upon it when withdrawn, showed that it had fitted tight. To insure a good fit, the top of the advance-bore had been brought to a suitable shape, and its inequalities removed, by means of a revolving cutting-tool. Herr Dunker remarks that this plan is adapted to a soft material like rock-salt, but that in ordinary hard rock it would be better to make the bottom of the main bore flat, and to close the advance-bore by an elastic disc pressed over it. The method of observation by advance-bores can only be employed during the sinking of the bore, a time when it is difficult to avoid error arising from the heat generated in boring. The expense of making an advance-bore at each depth at which an observation is required is also an objection to its use.

Another kind of plug devised by Herr Dunker, and largely used in the observations, consisted of a bag of very stout india-rubber (9 millimetres thick) filled with water, and capable of being pressed between two wooden discs, one above and the other below it, so as to make it bulge out in the middle and fit tightly against the sides of the bore. On the suggestion of bore-inspector Zobel, the pressure was applied and removed by means of screwing. Two steel springs fastened to the upper disc, and appearing, in Herr Dunker's diagram, very like the two halves of a circular hoop distorted into an oval by pressing against its walls, prevented the upper disc from turning, but offered little resistance to its rising or falling. The lower disc, on the contrary, was permitted to turn. Both discs were carried by the iron boring-rods. Rotation of these in one direction screwed the discs nearer together, and rotation in the other direction brought them further apart. The india-rubber bag could thus be made to swell out and plug the bore when it was at the desired depth, and could be reduced to its original size for raising or lowering. In order to prevent the boring-rods from becoming unscrewed one from another, when rotated backwards, it was necessary to fasten them together by clamps, a rather tedious operation in working at great depths.

In taking observations at other points than the bottom, two of these plugs were employed, one above and the other below the thermometer.

In some of the experiments, the apparatus was modified by using linen bags filled with wet clay, instead of indian-rubber bags filled with water; and, instead of screwing, direct pressure was employed, the lower disk being supported by rods extending to the bottom of the bore, while the upper disk could be made to bear the whole or a portion of the weight of the rods above it. Some successful observations were obtained with both kinds of bag; but the water-bags were preferred, as returning more easily to their original size when the pressure was removed, and consequently being less liable to injury in extraction. In some observations since taken in another place (Sudenberg), Herr Dunker states (in the private letter above referred to) that indian-rubber bags, filled with water, and pressed, not by screwing, but by the weight of the rods, were employed with much satisfaction.

All the methods of plugging employed by Herr Dunker involved the use of the iron rods belonging to the boring apparatus, and therefore would be inapplicable (except at great expense) after the operation of boring is finished and the apparatus removed.

It seems desirable to contrive, if possible, some plug that can be let down and raised by a wire. In the first report of your Committee, it was suggested that two bags of sand, one above and the other below the thermometer, should be used for this purpose. Bags of sand, however, would be liable to rub off pieces from the sides of the bore, and thus to become jammed in drawing up. Mr. Lebour has devised a plug which will be of small diameter during the processes of lowering and raising, but can be rendered large and made to fit the bore, when at the proper depth, by letting down upon it a sliding weight suspended by a second wire. Sir W. Thomson suggests that a series of indian-rubber disks, at a considerable distance apart, will probably be found effectual.

Mr. Boot has continued his observations in the bore which he is making at Swinderby, near Scarle (Lincoln). It has now been carried to the depth of 2,000 feet, and is in earthy limestone or calcareous shale, of carboniferous age. Its diameter in the lower part is only $3\frac{1}{8}$ inches. In April last the temperature, 78° F., was observed at 1,950 feet; and more recently 79° F.

was observed at 2,000 feet; the water, in each case, having been undisturbed for a month. Supposing these results not to be vitiated by convection, and assuming the mean temperature at the surface to be 50°, we have an increase of 29° in 2,000 feet, which is at the rate of 1° in 69 feet.

Mr. Symons has taken a series of observations at the depth of 1,000 feet in the Kentish Town well, with the view of determining whether the temperature changes. The instrument employed is a very large and delicate Phillips' maximum thermometer. The following is a list of the observations:—

Date of lowering.	Depth indicated. Feet.	Thermometer set at.	Date of raising.	Depth indicated. Feet.	Temperature. Fahr.
1874 —	1000	64·50	May 8	1007	66·82
,, May 8	1000	63·80	July 2	1009	(reading lost.)
,, July 2	1000	63·20	July 28	1005	67·40
,, July 28	1000	65·10	Sept. 8	1004	67 51
,, Sept. 8	1000	65·80	Sept. 29	1004	67·43
,, Sept. 29	1000	65·81	Oct. 30	1006	67·68
,, Oct. 30	1000	63·40	Dec. 3	1006	67·52
,, Dec. 3	1000	63·80	Jan. 7	1009	67·63
1875 Jan. 7	1000	63·75	Feb. 1	1006	67·56
,, Feb. 1	1000	63·90	March 3	1005	67·58
,, March 3	1000	63·90	May 3	1006	67·62
,, May 3	1000	63·95	June 1	1005	67·49
,, June 1	1000	63·00	July 7	1005	67·53
,, July 7	1000	63·87	Aug. 3	1004	67·58
,, Aug. 3	1000	63·87	Sept. 10	1004	67·58
,, Sept. 10	1000	64·00	Oct. 2	1003	67·58
,, Oct. 2	1000	63·90	Oct. 19	1004	67·62
,, Oct. 19	1000	63·80	Nov. 1	1005	67·62
,, Nov. 1	1000	63·70	Dec. 1	Wire broke.	

The "depth indicated" is shown by a measuring wheel or pulley, over which the wire runs by which the thermometer is raised and lowered, as described, with a diagram, in the Report for 1869. The above table shows that there is always some stretching, real or apparent, in the interval between lowering the thermometer and raising it again. Recent observations by means of a fixed mark on the wire, have shown that the change is not, in the main, a permanent elongation, but an alternation of length. It is probably due in part to the greater tension which the wire is under in raising than in lowering, a circumstance which will cause a temporary difference of length variable with the rapidity of winding up; also in part to the circumstance that the wire is warmer when it has just left the water than when it is about to be let down. Some portion of the irregularity observed may be due to variations of temperature in that part of the well (210 feet) which contains air. The observations taken as a whole, show that any variations of temperature which occur in this well at the depth of 1,000 feet, are so small as to be comparable with the almost inevitable errors of observation. The observations will be continued at intervals of six months, with additional precautions, and with an excessively slow (specially constructed) non-registering thermometer, in addition to the maximum thermometer hitherto employed.

Through the kindness of the eminent geologist, M. Delesse, of the Ecole Normale at Paris, observations have been obtained from the coal-mines of Anzin, in the north of France. They were taken under the direction of M. Marsilly, chief engineer of these mines. Maximum thermometers of the protected Negretti pattern, were inserted in holes bored horizontally to the depth of ·6 or ·7 of a metre in the sides of shafts which were in process of sinking, and in which there was but little circulation of air. A quarter of an hour was allowed to elapse in each case, after the boring of the hole, before the thermometer was inserted, and the hole plugged. Four different shafts were tried. Those designated as Nos. I., II., III., were in the mine Chabaud La Tour; and No. IV. was in the mine Renard.

In Shaft I. observations were taken at eight different depths, commencing with the temperature 56½° F. at the depth of 38·5 metres, and ending with 67¾° F. at 200·5 metres.

In Shaft II. there were observations at four depths, commencing with 55° at 87·3 m., and ending with 63½° at 185 m.

In Shaft III. there were observations at three depths, commencing with 56° at 87·8 m., and ending with 62½° at 144 m.

These three shafts, all belonging to the same mine, were very wet, and the temperature of the air in them was 11° or 12° C. (52° or 54° F.).

In Shaft IV., which was very dry and had an air temperature of about 15° C. (59° F.), observations were taken at 6 depths, commencing with 70¾° F. at 21·2 m., and ending with 84° F. at 134·8 m.

The mean rates of increase deduced from these observations are:—

In Shaft	I.,	1° F. in	14·4 m.,	or in	47·2 feet.
,,	II.,	,,	11·5 m.,	,,	37·7 ,,
,,	III.,	,,	8·65 m.,	,,	28·4 ,,
,,	IV.,	,,	8·57 m.,	,,	28·1 ,,

The observer mentions that in Shaft II. there was at the depth of 90 m. a seam of coal in which heat was generated by oxydation; but no such remark is made with respect to any of the other shafts, although it is obvious that some disturbing cause has rendered the temperatures in Shaft IV. abnormally high. Possibly the heat generated in boring the holes for the thermometers in this shaft (which was dry) has vitiated the observations, the instruments employed being maximum thermometers. Two of the slow non-registering thermometers mentioned in last year's Report have been sent to M. Delesse, to be used for verification.

The slow-action thermometers are constructed on the following plan:—The bulb is cylindrical and very strong, and is surrounded by stearine or tallow, which fills up the space between it and a strong glass shield in which the thermometer is inclosed. The shield is not hermetically sealed (not being intended for protection against pressure), but is stopped at the bottom with a cork, so that the thermometer can be taken out and put in again if desired. Stearine and tallow were selected, after trials of several substances, including paraffin-wax, bees'-wax, glue, plaster of Paris, pounded glass, and cotton wool. The thermometers are inclosed in copper cases lined with india-rubber. When placed, without these cases, in water differing 10° from their own temperature, they take nearly half a minute to alter by one-tenth of a degree.

In concluding this Report, your Committee desire to express their regret at the losses which they have sustained by the deaths of Prof. Phillips, Sir Charles Lyell, and Col. Strange, of whose valuable services they have been deprived within the last three years.

OUR ASTRONOMICAL COLUMN

THE ROTATION OF SATURN ON HIS AXIS.—On December 7 Prof. Hall, of the Naval Observatory at Washington, observed a very white spot on the disc of Saturn, just below the ring. At 6h. 18m., Washington mean time, the spot was central, and it was watched from 22h. 40m. sidereal time, to 0h. 10m., as it moved across the disc. It was small, very well defined, and from 2″ to 3″ in diameter. A rough ephemeris of its motion was sent to various observers in the U.S., and the observations which have been received are as below. The second column gives the time when the spot was central.

	Washington. M.T. h. m.	Place.	Observer.	o – c
1876, Dec. 7	6 18	Washington	Hall	...
10	6 11	Cambridge	A. G. Clark ...	– 8m
—	6 3	Hartford	D. W. Edgecomb	0
—	6 4	Poughkeepsie	M. Mitchell ...	– 1
—	...	Albany	L. Boss	...
13	5 47	Washington	Hall	0
—	5 50	,,	Eastman	– 3
—	5 38	Cambridge	A. G. Clark ...	+ 9

The column o – c gives the residuals when a rotation-time of 10h. 15m. is assumed. At Albany, on December 10, the spot was seen, but not until after passing the centre.

[It will be remarked that the time of rotation, supported by the above observations of a very definite spot, is in close agreement with the result obtained by Sir W. Herschel from noting the successive appearances of a belt during the winter of 1793-94,